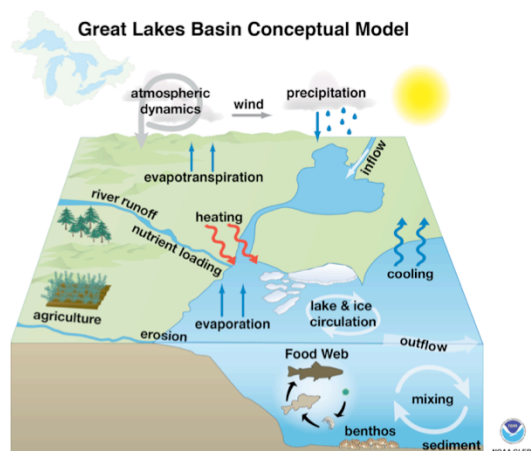


Integrated Physical & Ecological Modeling & Forecasting (IPEMF) Overview

Philip Chu, Ph.D., PE, MBA



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Align with NOAA's mission on
Climate Adaptation and Mitigation
Weather-Ready Nation
Healthy Oceans
Resilient Coastal Communities and Economies
Science Informed Society
Safety and Preparedness
Future Workforce

IPEMF Team

- Brent Lofgren – Climatologist
- Eric Anderson – Hydrodynamic Modeler
- Drew Gronewold – Hydrologist
- Jia Wang – Ice Climatologist
- Craig Stow – Ecosystem Modeler
- Anne Clites – Physical Scientist
- Greg Lang – Physical Scientist
- Tim Hunter – IT Specialist

- Becky Bolinger, Lisi Pei (UCAR PACE fellow)
- Jam Charusombat (NRC postdoc)
- Ayumi Manome, Dima Beletsky, Raisa Beletsky, Haoguo Hu, Andy Xiao, Heather Lucier, Joeseeph Smith, James Kessler (CILER)

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People first, mission always!

This team is highly skilled with diverse backgrounds and research interest, and are experts in their fields!

Brent is going to talk about Climate-land surface modeling (climate adaptation and mitigation)

Eric will cover the hydrodynamic modeling aspect and extreme event (weather ready nation and healthy ocean)

Drew will talk about hydrologic modeling

Craig will cover ecosystem modeling approaches and nutrient loading

IPEMF Goals

- Conduct innovative research and model development on key processes of the Great Lakes
- Transition research/models/tools/knowledge to operations and applications
- Promote internal and external collaborations
- Data management, data sharing and product dissemination

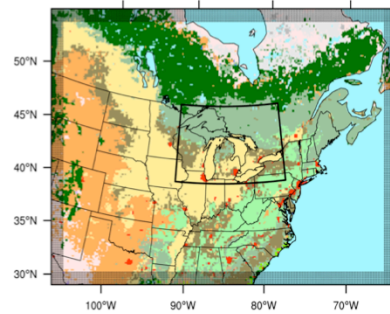
Climate Modeling – Brent Lofgren

Research and Development

- Climate Weather Research and Forecast Model (WRF) and RegCM4 (Regional Climate Model system) applications
- WRF-Hydro development for the Great Lakes
- Lake surface heat fluxes evaluation and comparison

Products & Services

- Extensive community outreach to decision makers and citizens



NOAA Goals: Climate Mitigation, Weather-Ready Nation

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WRF-Hydro | Weather Research and Forecast Model for Hydrology

GLOFS | Great Lakes Operational Forecast System

Hydrodynamic Modeling – Eric Anderson

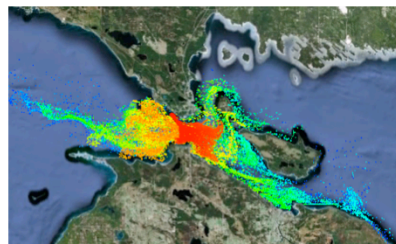
Research and Development

- HAB forecasting
- Contaminant transport
- Meteotsunami & extreme water level events

Research to Operations

- Next-Gen GLOFS to NOS
- LEOFS to NOS in April 2016
- 1 lake/yr for the next 5 years
- 2 RTAP (Research Transition Acceleration Program) funded to speed up transition

NOAA Goals: Weather-Ready Nation, Healthy Oceans, Resilient Communities



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NOS | NOAA National Ocean Service

LEOFS | Lake Erie Operational Forecast System

RTAP | Research Transition Acceleration Program

Hydrologic Research – Drew Gronewold

Research and Development

- Establish Great Lakes evaporation network
- Develop novel statistical models
- Develop WRF-Hydro framework for the Great Lakes

Transition to Operations (R2O)

- Water level forecast system for Niagara River to NYPA/OPG and NERFC
- AHPS and hydraulic model to USACE & IJC

Products & Services

- Serves on scientific and interagency committees
- Extensive public education and public outreach
- Various hydro-meteorological database and
- Long term water level software applications



NOAA Goals: Climate Mitigation, Weather-Ready Nation, Resilient Communities

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AHPS - Advanced Hydrologic Prediction System

NERFC – Northeast River Forecast Center

NYPA - New York Power Authority

OPG - Ontario Power Generation

Ice & Climate Research & Modeling – Jia Wang

Research and Development

- Coupled ice-ocean model for the Great Lakes and Arctic region
- FVCOM-Ice to evaluate long-term variability and climate change

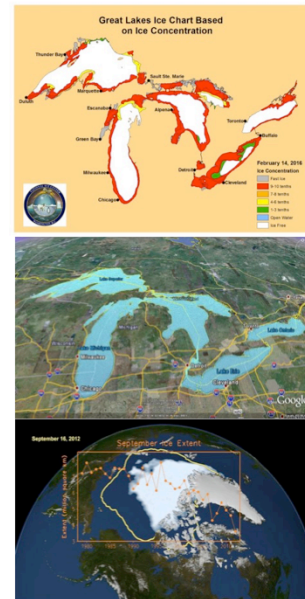
Transition and Application

- FVCOM-Ice for next-gen GLOFS

Products & Services

- Long-term Great Lakes ice coverage database and statistical model (34% ice coverage in 2016)

NOAA Goals: Climate Mitigation, Weather-Ready Nation



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FVCOM | Finite Volume Community Ocean Model is a modeling tool that enables high resolution (30 meters – 2 km) unstructured grid (i.e., triangular shapes of adaptable size) representation of the coastal system; a better approximation of the integral form of the equations of motion; tracking of seasonal lake level fluctuations; inflows and outflows at major connecting channels; expanded coverage to connecting waterways (Straits of Mackinac, St. Clair River, Lake St. Clair, Detroit River, upper St. Lawrence River).

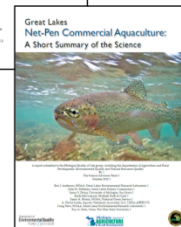
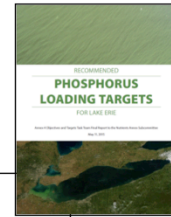
Ecosystem Research and Modeling – Craig Stow

Research and Development

- Bayesian network
- Ecological modeling
- Model uncertainty analysis

Products & Services

- Great Lakes Water Quality Agreement Annex 4 subcommittee on nutrient loading reduction
- OAR Modeling Uncertainty workshop
- Cladophora Workshop



NOAA Goals: Healthy Oceans, Resilient Coastal Communities

Innovative Research

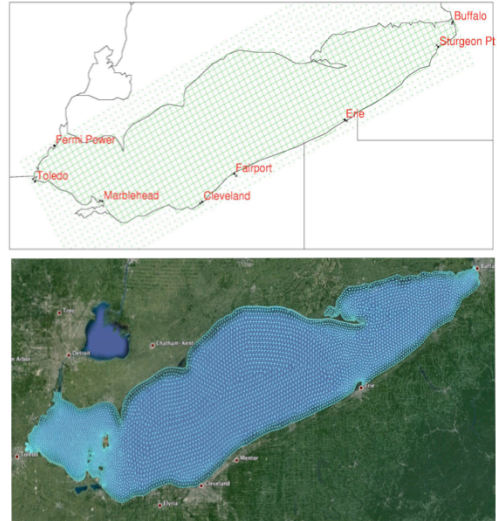
- Improve understanding of the interactions between the physical, biological, and ecological components of the whole Great Lakes ecosystem
- Develop and implement numerical models (climate, atmosphere, lake circulation, hydrology, wave, ice, and ecology) through improved physics, better forcing, higher spatiotemporal resolution

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Align with NOAA's mission on
Climate mitigation
Weather-ready Nation
Healthy Oceans
Resilient coastal community

What's new on the Next-Gen GLOFS?

- Unstructured grid Finite Volume Ocean Model (FVCOM) to resolve complex shoreline, channels and islands
- High spatial resolution (200m) with extended forecast range (120 hours out)
- Improved initial and boundary forcing fields
- Fully-coupled ice module to provide ice guidance



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Upgrade from 5km grid to 200 m in the coastal and bay areas.
Original Lake Erie has 1600 grid cells, the new Lake Michigan-Huron has more than 130,000 element!

Great Lakes Operational Forecast System R2O Transition Milestones



LEOFS transition
to NOS
in April, 2016

Lake Erie HAB tracker
to NOS/CO-OPS
2019

Coupled GL Lake-
Wave-Ice system
to NWS/NCEP
2025



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HEC - Huron-Erie Corridor

Collaborating Partners

NOAA

NOS: CO-OPS, NCCOS and CSDL

NWS: NCEP, NWC, WFO and RFC,

OAR: ESRL, PMEL, NSSL and GFDL

Other federal government agencies

Environment Canada, IJC, USACE, USGS, EPA, USCG

Academic Institutions

U. Michigan, U. Wisconsin, MTU, MSU, U. Toledo, Tulane U., CU Boulder, UNC Chapel Hill, NC State U., U. of Waterloo, Emory University

Stakeholders

NYPA, OPG, NRC, Limno-Tech, GLOS, and GLIN

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UW Madison: Meteotsunamis research. Thesis and dissertation research

MTU: Lake Superior long term climate impact and model coupling research

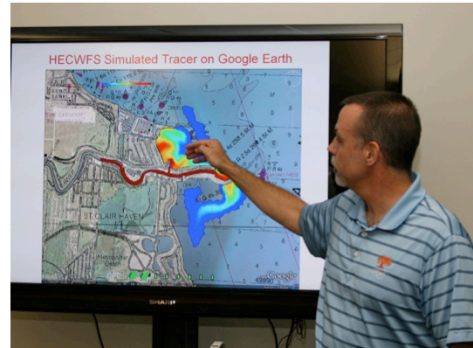
MSU: Climate-land surface interaction study

U Toledo: Bayesian network approach for nutrient loading

Tulane University: NOAA RESTORE project focusing on Mississippi River and Gulf of Mexico interactions
Thesis and dissertation committee

What's Next?

- Continue to conduct innovative research
- Continue to improve model accuracy and extend forecast capability
- Continue to promote collaboration
- Promote environmental data management and data sharing practice
- Rebuild in-house GIS capability

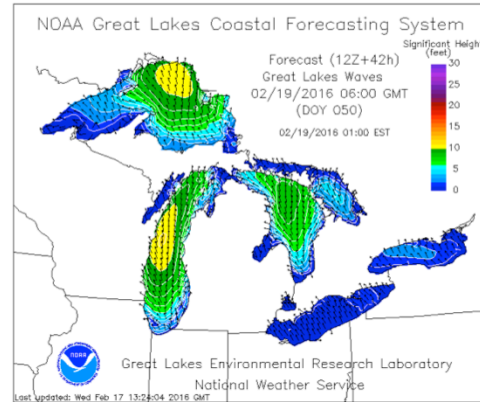


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Image: Meteorological data displayed using Google maps, G. Lang. September 2, 2010.

Model Improvement Strategy

- An integrated environmental modeling system through model coupling
- Data Assimilation using in-situ obs/satellite data to improve short-term forecast accuracy
- Ensemble probabilistic forecast to convey uncertainty for medium and long term forecasts

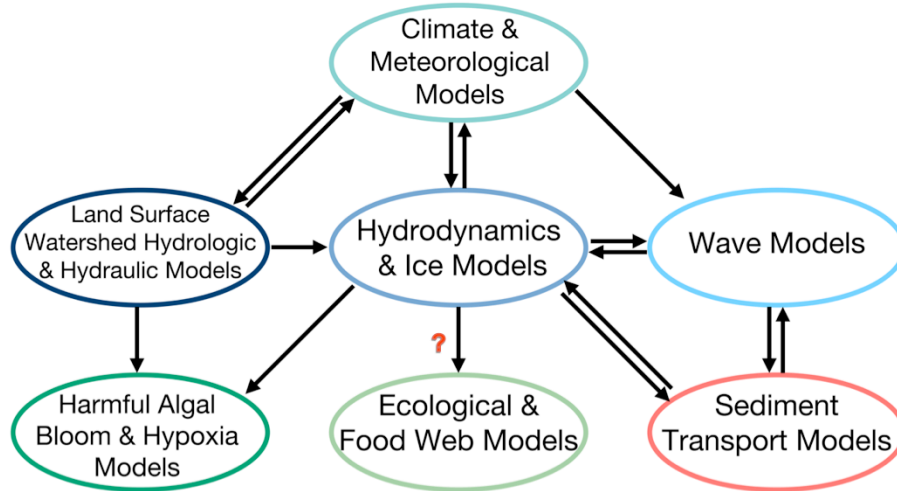


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For the past 10- 15 years, model improvements pretty much focus on improving model physics, processes, increasing spatial resolutions or improving boundary forcing. Each model (atmos, hydrodynamic, wave, hydrology) are run on either loosely coupled or uncoupled mode.

For the next 5-10 years, we plan to apply NOAA's objective of developing and implement an integrated environmental modeling approach.

An Integrated Environmental Modeling System



Summary

- IPEMF scientists conduct high quality, innovative research on all aspects of the Great Lakes ecosystem
- The knowledge and modeling systems developed are relevant and being transitioned to NOAA operational line offices and other government agencies
- Performance of the team is demonstrated in hi-impact publications, awards, patent and product transitions



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This team conducts high quality research, not limited to the Great Lakes, but also throughout other geographic regions, such as the Gulf of Mexico and the Arctic.

The research and products we produce are relevant to NOAA's mission and are transitioned to NOAA operational line offices and other decision-making agencies.

Images:

Top: Researcher D. Gronewold presentation on Great Lakes water levels at the Thunder Bay National Marine Sanctuary, Alpena, MI.

Bottom: Scientist Anne Clites is interviewed about water levels by Alpena News at Thunder Bay National Marine Sanctuary, June 27, 2013.

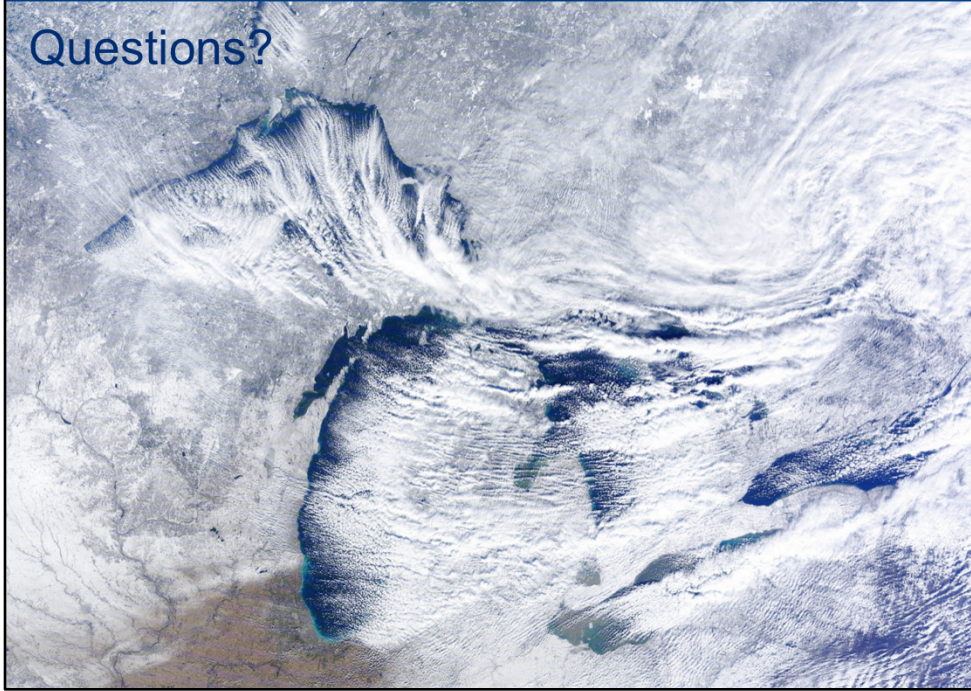
What do our product users say

- “We look at GLOFS wind, wave, ice forecasts everyday for search and rescue missions (SAR), GLERL’s products save lives!” Jerry, USCG 9th District Cleveland Office
- “We regularly check GLOFS forecasts for high/low water levels and waves for all the nuclear power plants operation around the Great Lakes!” Jack, Nuclear Regulatory Commission
- “We use GLOFS water level forecasts to determine how much water to release to Niagara River, accurate forecasts save \$30M/year!” Peter, (NYPA)

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We held a community user outreach meeting for the next generation of GLOFS in last October. For years we know the system and products we produced are very popular for commercial and recreational fishermen, and surfers. What we did not expect is the heavy users from the above industry!

Questions?



Recommendations from 2010 science review

- Continue to develop the increasing important connection to NOAA's National Ocean Service (including CSDL and CO-OPS)
- Continue to develop and communicate complex model forecast results and uncertainty in critical areas related human health and safety

[Additional Information](#)

Hold weekly GLOFS conference call between GLERL, CSDL and CO-OPS to discuss status and issues
Quarterly meeting with modeling advisory panels and gateway manager to check progress and milestone schedule
Biannual face-to-face meeting and workshop at Silver Spring

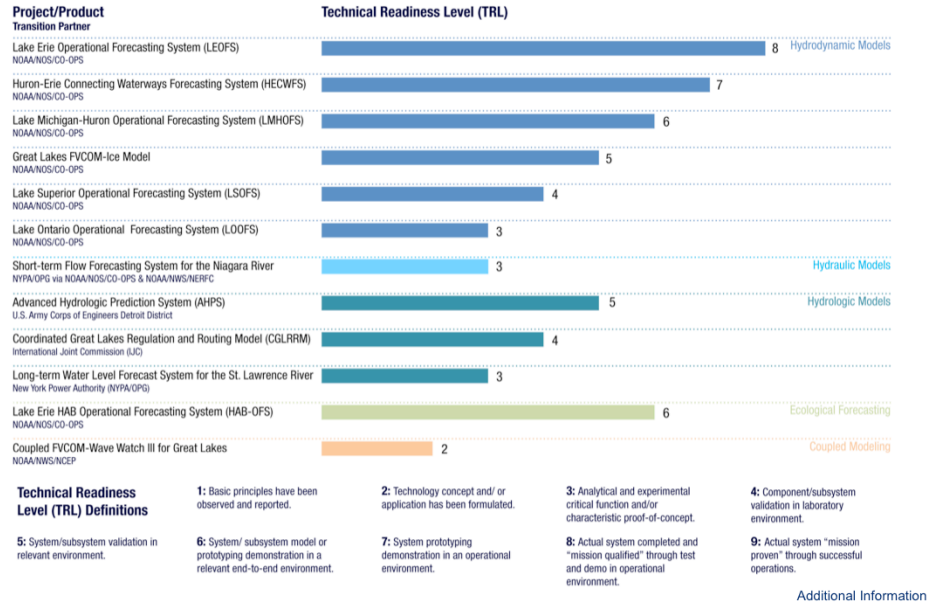
Integrated modeling approach to predict hypoxia, HABs and other ecological and water quality parameters

Brief History of IPEMF's R2O effort

- 1989: Developed GLFS with OSU
- 1991: First 3-D Lake Erie nowcast on CRAY
- 1992: GLFS workstation version running at GLERL
- 1993: First 3-D forecasts
- 2000: GLFS team won the AMS Special Award
- 2003-2005: Transitioned GLFS to NOS/CO-OPS
- 2016-2021: Next-generation GLOFS being transitioned to NOS/CO-OPS and NWS/NCEP

[Additional Information](#)

Transition to Operations (R2O)



Transition to Applications (R2A)

